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# ***JPRS Report***

## **Science & Technology**

***USSR: Materials Science***

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SCIENCE & TECHNOLOGY  
USSR: MATERIALS SCIENCE

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ANALYSIS, TESTING

UDC 669.715:620.163.4

Structural Characteristics of Fracture Surface of Rolled Al-Zn-Mg Alloy

18420041 Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV  
in Russian No 10, Oct 87 pp 59-61

[Article by A.A. Artsruni, N.F. Kuzovova, S.M. Nefedova and B.D. Chukhin]

[Abstract] A study was made concerning the fracture of a rolled Al-Zn-Mg alloy with up to 9 wt.% Zn+Mg. Two specimens of such an alloy were notched and then broken, one in the state of maximum strength after aging at 100°C for 24 h and one in the overaged state after aging at 175°C for 5 h. The fracture surfaces of the first specimen were dry and dull with serrations indicating schistosity. The fracture surfaces of the second specimen were spotwise brilliant, softer, and smoother with only small pits indicating ductility. The depthwise distribution of alloying elements (Zn,Mg) and impurity elements (Fe,Si) under the fracture surfaces was determined on the basis of local spectral microanalysis of dull and brilliant spots respectively, using an LMA-10 Karl Zeiss (GDR) laser with a highly sensitive photographic camera. The results reveal that overaging such an Al-Zn-Mg alloy will prevent flaking. References 1: Russian.

2415/9604

UDC 620.197.3

## Inhibitors of Metal Corrosion Based on Wax From Sugar Cane and Containing Nitrogen

18420027a Moscow ZASHCHITA METALLOV in Russian Vol 23, No 5, Sep-Oct 87  
(manuscript received 2 Jun 86) pp 768-773

[Article by V.M. Ledovskikh, H.D. Gonzales Rigotty and Yu.P. Shapovalova,  
Kiev Polytechnical Institute]

[Abstract] Development of corrosion inhibitors in the amide and imidazoline class on the basis of wax abundantly available from sugar cane for protection of metals against aggressive two-phase media in Cuba's petrochemical industry is reported. Raw wax is first fractionated into solid wax, fats, and resins before amides of carboxylic acids or 2-alkyl imidazolines are synthesized. All reactions leading to their synthesis were individually and independently monitored by chemical and spectral analyses of intermediate and final products. The results of corrosion tests performed on St3 plain carbon steel in a petrochemical environment, a mixture of water or  $\text{NH}_4\text{Cl}$  solution in water and gaseous hydrocarbons with or without  $\text{H}_2\text{S}$  at temperatures up to  $110^\circ\text{C}$ , indicate that the inhibitors of both series are as effective as or more effective than imported Norust PR and Corromin E-2. References 29: 10 Russian, 10 Cuban (3 in Russian translation), 9 Western (3 in Russian translation).

UDC 620.198

Corrosion Resistance of Ti-Pd-Alloy Surface Layers Produced by Polyenergetic Implantation of  $\text{Pd}^+$ -Ions Into Titanium

18420027b Moscow ZASHCHITA METALLOV in Russian Vol 23, No 5, Sep-Oct 87  
(manuscript received 26 Mar 86, after revision 24 Jul 86) pp 791-795

[Article by N.D. Tomashov, I.S. Tashlykov, O.A. Zhiltsova, G.P. Chernova, M.I. Guseva and B.G. Vladimirov, Physical Chemistry Institute, USSR Academy of Sciences, Scientific Research Institute of Applied Physical Problems imeni A.N. Sevchenko, Atomic Energy Institute imeni I.V. Kurchatov]

[Abstract] An experimental study of surface layers on titanium produced by implantation of  $\text{Pd}^+$ -ions was made to investigate the feasibility of raising their corrosion resistance by not only increasing the total Pd content but also optimizing the depthwise Pd-concentration profile. Specimens of

VT-1 titanium, disks 12 mm in diameter and 3 mm thick, were electrolytically polished and then bombarded with  $\text{Pd}^+$ -ions on one side. Mounted in a teflon holder, they were then tested for corrosion with that side in contact with 20% aqueous  $\text{H}_2\text{SO}_4$  solution at a temperature of  $100^\circ\text{C}$ . The results indicate that the corrosion resistance of Ti surface is not necessarily raised by increasing the total Pd content but can be raised by improving the Pd-concentration profile through polyenergetic implantation of  $\text{Pd}^+$ -ions. The best result, namely maximum penetration down to 80 nm depth with minimum variance of the concentration profile, was obtained by implanting first a  $10^{16} \text{ cm}^{-2}$  dose of 85 keV  $\text{Pd}^+$ -ions and then a  $10^{16} \text{ cm}^{-2}$  dose of 40 keV  $\text{Pd}^+$ -ions. In order that the Pd-alloyed titanium surface layer remain in the passive state for a long time, it is necessary that palladium act not only as catalyst of the cathodic reaction which releases hydrogen and shifts the potential of the surface into the passivity range for titanium but also as electron donor in the passivating oxide (semiconductor) film which forms on the surface in contact with the corrosive medium. References 8: 4 Russian, 4 Western.

UDC 620.195

#### Structure and Electrochemical Behavior of Oxide Films on $\text{Ni}_{60}\text{Nb}_{40}$ Alloy in Amorphous and Crystalline States

18420027c Moscow ZASHCHITA METALLOV in Russian Vol 23, No 5, Sep-Oct 87 (manuscript received 20 Jun 86) pp 796-800

[Article by N.D. Tomashov, I.B. Skvortsova, A.Ye. Gorodetskiy and D.B. Bogomolov, Physical Chemistry Institute, USSR Academy of Sciences]

[Abstract] An experimental study of the  $\text{Ni}_{60}\text{Nb}_{40}$  alloy in both amorphous and crystalline states has revealed a correspondingly different electrochemical behavior of the oxide films forming on its surface during anodic polarization in electrolytes such as a mixture of aqueous NaCl and HCl solutions. Amorphous 70  $\mu\text{m}$  thick and 2 mm wide ribbons were produced at the Institute of Metallurgy by spinning while cooling the melt at a rate of  $10^8^\circ\text{C/s}$  in an argon atmosphere. Such ribbons were crystallized by annealing at a temperature of  $800^\circ\text{C}$  under a residual pressure of  $10^{-7} \text{ mm Hg}$  for 1 h, with slight embrittlement caused by nonmetallic inclusions. Both kinds of ribbons were anodically polarized by the potentiodynamic method at a rate of 50 mV/min in a 2n. NaCl solution at room temperature, addition of HCl acidifying the solution to a pH= 0. Within the passivity range of potentials the anodic current density was one order of magnitude lower at the surface of amorphous alloy than at the surface of crystalline alloy, while within the Cl-evolution range it was two orders of magnitude higher. Microstructural examination under a transmission electron microscope and phase microanalysis in an x-ray diffractometer revealed respectively amorphous and crystalline  $\text{Nb}_2\text{O}_5$  oxide films, with  $\text{Ni}_n\text{Nb}$  quasi-intermetallic compounds forming inclusions in the latter. The results indicate that the amorphous alloy is much more easily passivated and its passive state remains more stable, the anodic current being more stable within both passivity and Cl-evolution ranges. References 9: 5 Russian, 4 Western.



Effect of Alloying Aluminum With Tin on Its Corrosion and Electrochemical Behavior

18420027d Moscow ZASHCHITA METALLOV in Russian Vol 23, No 5, Sep-Oct 87  
(manuscript received 26 Jun 86, after revision 12 Jan 87) pp 801-805

[Article by V.S. Sinyavskiy, V.D. Valkov, G.M. Toguzov and L.S. Guzey,  
Moscow Institute of Petroleum and Natural Gas imeni I.M. Gubkin, All-Union  
Light Alloys Institute]

[Abstract] An experimental study of Al-Sn alloys was made for a determination of the effect of Sn on their electrochemical behavior and the dependence of their corrosion rate on the Sn content in a neutral Cl-salt medium. Alloys with 0.01-5.0 wt.% Sn were produced by smelting 99.99% pure Al and 99.937% pure Sn in corundum crucibles in a silite furnace and subsequent casting into a copper chill-mold. All castings were rolled into 1 mm thick sheet from which flat specimens were punched out for heat treatment in quartz containers filled with pure helium. They were then quenched,  $\alpha$ -phase low-Sn alloys from 600°C and ( $\alpha + \beta$ )-phase high-Sn alloys, including the eutectic one, from 200°C. All were tested for corrosion in an aqueous 3% NaCl solution with 0.1% H<sub>2</sub>O<sub>2</sub> according to standard procedure and the loss of mass measured after 1-3-6 months. Their electrochemical behavior in aqueous 3% NaCl solution was monitored with a P5827M potentiostat. Their corrosion when touching bare St3 plain carbon steel with a 1:1 ratio of areas in contact was also measured in the same solution. For reference, identical tests were performed on plain Al and on St3 plain carbon steel alone. Microstructural examination and phase analysis were done under a "Neophot 2" optical microscope and in a DRON-2 x-ray diffractometer respectively. The results reveal uniform corrosion of Al-Sn alloys without pitting, both  $\beta$ -Sn and Al<sub>2</sub>O<sub>3</sub>.H<sub>2</sub>O (boehmite) forming on the surface of the Al+ 5.0% Sn alloy. Increasing the Sn content within the  $\alpha$ -phase range was found to shift the corrosion potential in the negative direction so as to enhance the anodic process resulting in dissolution of Al. The corrosion resistance of steel was found to decrease appreciably, by up to an order of magnitude, when in contact with  $\alpha$ -phase Al alloy (0.01% Sn) and also when in contact with ( $\alpha + \beta$ )-phase Al alloy. While therefore Al alloys with low Sn content (0.01-0.02%) effectively protect steel against corrosion, Al alloys with high Sn content are not suitable as sacrificial protectors because of the high self-dissolution current. References 4: all Russian.

# Electrochemical Behavior and Corrosion of Al-B Composite Material in NaCl Solution

18420027e Moscow ZASHCHITA METALLOV in Russian Vol 23, No 5, Sep-Oct 87  
(manuscript received 20 Jun 86) pp 806-814

[Article by V.D. Kiselev, V.I. Kolotyarkin, V.M. Knyazheva, Ye.F. Koloskova and S.G. Prutchenko, Physical Chemistry Scientific Research Institute imeni L.Ya. Karpov]

[Abstract] A high-strength light-weight composite material consisting of an aluminum matrix and 25 vol.% boron fiber was tested for corrosion in a basic 0.5 M NaCl solution simulating sea water. The boron fiber was 0.14 mm in diameter and the AD1 aluminum alloy had a total impurity content (Fe, Si, Zn, Cu, Mg, Mn) not higher than 0.825 wt.%. Plates of this material were stacked together by "monofoil" diffusion welding in vacuum under a pressure of 35 MPa, three groups of stacks being thus produced by welding at 530°C for 60 min, at 530°C for 20 min, and at 500°C for 20 min respectively. The active surface of each stack was ground with diamond powders of successively smaller grain sizes and then etched with aqueous 10% NaOH solution for 30s. After removal of the strained layer by this treatment, it was rinsed with pure water and dried with filter paper. Electrochemical measurements were made by the potentiodynamic method in a cell with the main electrode and the auxiliary one in separate compartments. Quantitative analysis for aluminum content in the solution after holding for 2-8 h at various potentials ranging from +1.7 V to -1.7 V, with the current density ranging correspondingly from +1.8 mA/m<sup>2</sup> to -11 mA/m<sup>2</sup>, was based on atomic-absorption spectrometry in a C<sub>2</sub>H<sub>2</sub>-N<sub>2</sub>O flame and in a graphite cell with a Perkin-Elmer instrument. Periodic sampling for measurement of the aluminum dissolution kinetics was done for 100 h. Examination of samples for corrosion defects was done under a JSM-2 scanning electron microscope. The corrosion potential for the composite material was found to be -0.58 V, those for the aluminum alloy alone and the boron fiber alone being -0.59 V and +0.25 V respectively. The dependence of the corrosion rate on the potential was found to consist of three distinct ranges corresponding successively to cathodic corrosion at higher positive potentials passivation from +0.25 V to -0.59 V, and pitting at lower negative potentials. Both cathodic and anodic processes were found to be inhibited at the boron fiber, the latter exhibiting a high corrosion resistance over a 1160 h test period. The aluminum matrix of the composite material was found to have a lower corrosion resistance than the aluminum alloy alone at potentials more negative than the pitting potential. The electrochemical behavior of all stacks was found to be essentially the same and thus not to depend on the temperature-time parameters of the welding process. The authors thank Ya.M. Kolotyarkin for valuable comments and A.V. Sergeyev and Ye.S. Syropayeva for supplying specimens of the composite material. References 20: 16 Russian, 4 Western (1 in Russian translation).

2415/9604

UDC 669.295:621.762

Dependence of Properties of Electrolytic Titanium Powders on Electrolyte Composition

18420040a Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 87 (manuscript received 21 Jan 86) pp 6-10

[Article by G.P. Dovgaya, V.V. Nerubashchenko, S.P. Chernyshova, and L.K. Mineyeva, All-Union Scientific Research Institute of Titanium]

[Abstract] An experimental study of titanium powders produced electrolytically from four different solutions was made for the purpose of comparing them in terms of chemical composition and structural characteristics as well as microhardness and technological characteristics. The four electrolytes containing 2.8-3.2 wt.% Ti each were one chloride solution and three chloride+fluoride solutions with F:Ti= 1:5, 1.5:1, 6:1 weight ratios respectively. The parameters of the refining process were identical in each case: temperature 750-850°C, anode current density 0.2-0.3 A/cm<sup>2</sup>, initial cathode current density 0.6-1.0 A/cm<sup>2</sup>, duration of one electrolysis cycle 3 h. The results reveal a much lower Fe, N<sub>2</sub>, Cl content and a slightly higher O<sub>2</sub> content in Ti powders produced with chloride+fluoride electrolytes. All powders included polyhedral grains with a microhardness within the 1780-2450 MPa range, powders with a higher O<sub>2</sub> content including dendritic grains and having a microhardness of up to 5000 MPa. Increasing the fluoride content in the electrolyte was found to make the -0.63+ 0.18 mm grain size fraction more dominant and to appreciably increase the specific surface, while decreasing the +0.63 mm grain size fraction and the bulk density, and also to lower the flowability of the powder and its concentration threshold of sputterability. References 3: all Russian.

# Structure and Properties of Niobium Powder Produced From Niobium Chips By Hydrogen Treatment

18420040b Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 87 (manuscript received 28 Dec 86) pp 10-13

[Article by G.F. Kobzenko, N.S. Kobzenko, A.A. Flis and V.D. Valentinov, Metal Physics Institute and Institute of Materials Science Problems, UkSSR Academy of Sciences]

[Abstract] An experimental study was made concerning the production of Nb powder from Nb chips by the hydrogenation--decomposition--dehydrogenation method, pure hydrogen for this purpose having been obtained by desorption from  $TiH_2$  and  $LaNi_5H_6$ . The object was to determine the kinetics of hydrogen absorption and liberation processes, including the temperature dependence of hydrogen pressure above, and hydrogen content in niobium during heating up to, 695 K. Structural examination of the powder and chips, also of monolithic niobium for comparison, was done in a "Superzond-733" x-ray microanalyzer as well as under a DZh SM-20T electron microscope and a "Neophot" optical microscope. Density was measured by the weighing method on a VLP-20G balance and microhardness was measured with a PMT-3 tester. The results indicate a decrease of the oxygen content from 0.031% in Nb chips to 0.005% in Nb powder and a compactibility of Nb powder from  $2.6 \text{ g/cm}^3$  to  $5.3 \text{ g/cm}^3$  under a pressure of 280 MPa. References 5: 4 Russian, 1 Western.

UDC 621.762:669.245

## Some Properties of Iron Powders With Cobalt or Ni-Co Alloy Plating

18420040c Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 87 (manuscript received 11 Mar 86) pp 13-16

[Article by L.M. Kurvyakova and V.I. Yurov, Moscow Chemical Technology Institute, Novomoskovsk branch]

[Abstract] An experimental study of electrolytically plated iron powders was made, with cobalt coating produced by deposition from a  $450 \text{ g/dm}^3$   $CoSO_4 \cdot 7H_2O + 40 \text{ g/dm}^3 H_3BO_3 + 15 \text{ g/dm}^3 NaCl$  solution and with coating of 70% Ni + 30% Co alloy produced from a  $195 \text{ g/dm}^3 NiSO_4 \cdot 7H_2O + 35 \text{ g/dm}^3 CoSO_4 \cdot 7H_2O + 30 \text{ g/dm}^3 H_3BO_3$  solution (pH=3.2-4.0). Plating was done at a temperature of  $25^\circ C$ , maintained by cooling the electrolytic trough while the electrolyte was circulated at a rate of 150-200 ml/min, with an anode current density of  $10-12 \text{ A/dm}^2$  on powder having a surface density of  $50 \text{ g/dm}^2$ . The weight fraction of plating metal (Co) or alloy (Ni-Co) was varied over the 5.7-30.2% range, by varying the electric charge passed over the 0.11-0.58 A·h/g range. Coatings which constituted 6-8 wt.% of the powder were found to be complete and uniform, those constituting up to 30 wt.% being still adequately uniform. Iron powders were also plated by successive

deposition of nickel and then cobalt, the two layers becoming so tightly bonded as to merge without distinct boundary between them and the coating remaining uniform even when constituting up to 40 wt.% of the powder. Compactibility of these powders to a density up to 6.60 times higher was found to be attainable under a load of 7 tons and annealing at a temperature of 500°C in an argon atmosphere to further improve it to 4.6 g/cm<sup>3</sup>. References 4: all Russian.

UDC 621.762.4

#### New Trend in Compaction for Manufacture of Long Parts From Powder Materials

18420040d Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 87 (manuscript received 15 Mar 87) pp 28-33

[Article by L.S. Boginskiy, Belorussian Polytechnical Institute]

[Abstract] The new trend in the manufacture of long parts from powder materials is progressive lengthwise compaction, found to be safer as well as more efficient and economical than conventional simultaneous compaction of the entire mass. Such a compaction of axisymmetric products such as tubes, for instance, is preceded by preliminary axial or preferably radial compaction of the entire mass to up to 50% ideal density. Subsequent progressive compaction can be done through an elastic buffer medium onto a mandrel or onto a dye, also in the viscous friction mode. Various methods and tools have been developed for improvement of this process. These include compaction between rollers and compaction through sleeves of plain or reinforced polyethylene, or polyurethane, cyclic compaction, and impact compaction. Details of their design depend on the product: bare or clad tubes, bare or clad strips. References 13: all Russian.

UDC 621.951.1:621.762:621.922.34

#### Structure and Properties of Extruded Abrasive Metal-Base Composites

18420040e Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 87 (manuscript received 13 Feb 86) pp 57-60

[Article by N.V. Manukyan, G.S. Apoyan, V.L. Kasyan and I.Z. Yegoyan, Yerevan Polytechnical Institute]

[Abstract] An experimental study of abrasive metal-base composites was made for a comparative evaluation of extruded and hot-pressed material. Electrocorundum 23A grains (315/250, 160/125, 80/63) were coated with M1 binder. Cylindrical test specimens 12 mm in diameter and 15 mm high were produced by bilateral compaction under a pressure of 160 MPa and subsequent sintering at 700-770°C in a mold in air, with hot aftercompaction under a pressure of 100 MPa. The results of microstructural examination and mechanical tests indicate that extruded material has higher compressive

and flexural strength as well as shear and impact strength, also a higher Brinell hardness value and a higher thermal conductivity, evidently because of a much lower porosity of the powder and a better adhesion of the binder. References 5: all Russian.

UDC 621.762.224

# Installation for Production of Metal Powders by Centrifugal-Hydraulic Method

18420028a Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 87 (manuscript received 1 Oct 86) pp 1-3

[Article by Sh.M. Sheykhaliev, V.V. Kuzmin and Ye.V. Luzin, Moscow Engineering Physics Institute, Department II]

[Abstract] An installation has been designed and built at the Moscow Engineering Physics Institute for production of nonferrous metal and alloy powders on a semi-industrial scale by the centrifugal-hydraulic method. It consists of a 2.8 m high column formed by a cylindrical smelting chamber on top, a wider cylindrical atomizing chamber with a 0.8 m inside diameter in the middle, and a conically tapering collector underneath. The smelting chamber contains a crucible made of stainless steel or graphite with a 10 dm<sup>3</sup> capacity and with a round bottom, surrounded by a Nichrome heater coil and terminating into a funnel. Melt flows down through this funnel, with a vertical stem turned by a wheel on top acting as valve, into a centrifugal nozzle or three of them held in a fixture at the entrance to the atomizing chamber. The nozzle set with holder, also made of stainless steel or graphite, is warmed up by a separate heater. The atomizing chamber is water-cooled from outside so that the mist solidifies into powder while dropping into the collector. Melting and atomization take place in an inert atmosphere of nitrogen or noble gas (helium, argon) pumped into the column after evacuation. Hermeticity of smelter-atomizer and atomizer-collector joints is maintained by a vacuum system which includes a fore-vacuum pump and an oil-vapor set as well as a vacuum gauge and a manometer. Temperatures of the melt in the crucible and of the nozzle set in the holder are maintained by a control system with the aid of Chromel-Alumel thermocouples and a KSP-4 potentiometer. The power of each heater is controlled by means of a voltage regulator. Pressure above the melt is maintained by admission of gas from standard high-pressure tanks through valves. The installation is designed for metals whose melting point is not higher than 1273 K. It was tested on grade-1 tin and on 61Sn-Pb solder, as well as on an aluminum alloy, fine powder with a very low oxygen content having been produced in each case. References 2: both Russian.

## Structure and Mechanical Properties of Deformed W-Re Powder Alloys

18420028b Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 87 (manuscript received 17 Jun 86) pp 88-92

[Article by Yu.N. Podrezov, O.G. Radchenko, N.G. Danilenko, V.V. Panichkina, V.I. Gachegov and A.B. Olshanskiy, Institute of Materials Science Problems, UkSSR Academy of Sciences]

[Abstract] An experimental comparative study of sintered W+ 0.2% Re and W+ ( $Y_2O_3, Hf_2O_3$ ) alloys was made for the purpose of determining their viscoelastic transition temperature and its anisotropy as well as the temperature dependence and the anisotropy of their flexural yield point, ultimate flexural strength, and cracking resistance after 80% mechanical reduction by rolling into 2 mm thick strip and after subsequent recrystallization by annealing at a temperature of 1800°C for 2 h. For reference, sintered commercially pure tungsten was identically treated and tested. Specimens for strength tests were cut parallel to and perpendicularly to the direction of rolling. Flexural tests were performed by the 3-point method. Specimens for viscoelasticity transition tests were cut in four planes: in two (x,y) planes and two (x,z) planes when cut in the x-direction parallel to the direction of rolling, in two (x,y) planes and two (y,z) planes when cut in the y-direction perpendicular to the direction of rolling. The highest temperature at which a specimen could still be bent through a 90° angle, corresponding to a 7.2 mm deflection, without fracture was regarded as the viscoelastic transition temperature. Test temperatures covered the range from -196°C to 450°C. Structural examination of specimens after tests was done under a T-20 scanning electron microscope and by fractography, the latter indicating transcrystalline fracture with shear in each case. The results reveal that the W+ 0.2% Re alloy has the lowest yield point throughout the entire temperature range and also the lowest viscoelastic transition temperature, -50°C in the direction of rolling and 30-70°C in the other direction, while commercially pure tungsten is least plastic. Recrystallization was found to raise the viscoelastic transition temperature appreciably, thus degrading the plasticity, and also to remove the anisotropy. Both sintered alloys are more plastic than the cast ones, their other mechanical characteristics being comparable. References 6: 5 Russian, 1 Western (in Russian translation).

# Structural Peculiarities and Cutting Characteristics of BN-Based Superhard Materials

18420028c Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 87 (manuscript received 9 Apr 86) pp 92-97

[Article by G.G. Karyuk, A.V. Bochko, V.M. Volkogon, S.S. Dzhamarov, P.V. Zakharenko and V.S. Silvestrov, Institute of Materials Science Problems, UkSSR Academy of Sciences]

[Abstract] A study of polycrystalline superhard materials on a BN base for cutting tools was made for a comparative evaluation of the various such materials produced in the USSR (Hexanite-P, Elbor-P, Belbor, PTNB, Kiborite, Niborite). Electron microfractography has revealed that Hexanite-P has the finest and most homogeneous grain dispersion. Its BN base is known to consist of wurtzite with 40-60% sphalerite and 1-2% graphite-like phase. It also has the best cutting characteristics, all materials having been tested in turning Cr-W-Mn steel on a 16K2 lathe with impact 0.2 mm deep at the same speed of 70-80 m/min and the same feed rate of 0.075 mm/rev. Additional tests have shown that cutter plates with a Hexanite-P layer supported by a layer of high-strength hard alloy are more stable and can operate at higher feed rates up to 0.15 mm/rev. Production of such cutter plates in the polyhedral version has already been set up at the Poltava Synthetic Diamonds and Diamond Tools Plant and at the Yerevan Almaz Production Association. The authors thank G.S. Oleynik for assisting in the structural examination and participating in the discussion of the results. References 5: all Russian.

UDC 621.762.4.001.5

## Dependence of Properties of Powder-Metal Preformations on Compaction Method

18420038a Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian, No 9, Sep 87 pp 2-3

[Article by G.A. Krivonos, R.Ye. Murashko, B.V. Rozanov and N.V. Ryazanova]

[Abstract] Preformations of three metal powder materials were produced by hydrostatic compaction and by hydrodynamic compaction, the purpose being to determine the dependence of their mechanical properties on the compaction method. These materials were electrolytic Fe powder (bulk density 2.2 g/cm<sup>3</sup>), Mo powder (bulk density 2.65 g/cm<sup>3</sup>), and Fe + 1.2 graphite + 1.2% Cu + 1.5% Mo powder (bulk density 3.16 g/cm<sup>3</sup>). They were hydrostatically compacted under pressures up to 500 MPa for 30-45 s in containers with a 150 mm inside diameter. They were hydrodynamically compacted with a plunger moving down on a column of liquid driven by the gaseous products of gunpowder explosion. Specimens 28-32 mm and 48-52 mm in diameter and 50-55 mm high, pressed inside elastic rubber or polyurethane beakers were tested for tensile and compressive strength, their density being measured



by hydrostatic weighing. The results reveal that all preformations are 3-5 times stronger in compression than in tension, thus qualifying as brittle materials. Those produced hydrodynamically were found to be stronger, performances of the Fe powders some 1.5-3 times, than those produced hydrostatically and having the same bulk density. References 4: all Russian.

UDC 621.73.043.001.13

Problems in Efficient Utilization of Superplasticity in Pressure Treatment of Metals

18420038b Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 9, Sep 87 pp 3-6

[Article by O.M. Smirnov]

[Abstract] The criterion for viscous flow of a superplastic material is established on the basis of pressure-stress relations, whereupon the theory of superplastic deformation is applied to pressure treatment of metals with emphasis on the three main advantages of superplastic over plastic deformation: 1) much smaller zones of high deformation resistance under the tool; 2) more uniform deformation and easier flow of metal into grooves in the die, especially into sharp corners; 3) more stable deformation without strain localization under linear or plane stresses. Application of the superplastic-deformation technology to metal products draws heavily on an analogy with and adaptation from conventional reprocessing of glass and thermoplastic products. Superplasticity appears to be most efficiently utilizable in forging of metal strip by action of compressed gas on the ram according to positive-action, negative-action, or hybrid-action schemes, in thermoelastic punching of thin-walled metal shells with stiffeners, and in extrusion of intricately shaped metal articles by "solid state" casting, especially when these processes are combined with diffusion welding. The main problems in implementation of this new treatment of metals are optimization and control of the process parameters, particularly the temperatures and the deformation rates. While temperature control is readily ensured by means of isothermal heating blocks, the deformation rate must be sufficiently low to ensure superplastic flow without adversely affecting the productivity. This can be achieved by redesign of existing equipment, also by use of conventional equipment with constant-pressure creep compression or with periodic pressure boosting in the final and relatively short stage of the forming process. Another problem, also requiring unconventional solution, is product quality assurance. References 7: all Russian.

# Program Package for Computer Simulation of Groove Filling During Combined Cold and Hot Extrusion

18420038c Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 9, Sep 87 pp 9-11

[Article by L. Cser, G. Ziaja, and L. Lerinc]

[Abstract] A program package has been put together for computer-aided design of combined cold and hot extrusion or forging, with simulation of the groove filling process critical in forming of metals under compression. The input data are tool dimensions and billet dimensions, billet material, known inlet velocity, and elementary process discretization step. The mathematical model is the equation of energy balance in purely plastic flow or hardening within fixed boundaries but with variable metal-tool interface. It is formulated according to the variational principle for total deformation power with time discretization and corresponding increments of work done by internal forces and by external forces. The design problem reduces to minimization of the shearing energy functional in the kinematically possible velocity field and prevention of tool breakage. The algorithms have been programmed for an SM-4 minicomputer so as to facilitate design in the interactive mode. They are being reprogrammed for a PROPER 16A microcomputer (made in Hungary) with a 256 kbyte core memory, a two-disk external memory, and a VIDEOTON 2020 graph plotter. References 7: 1 Russian, 1 Hungarian, 5 Western (2 CIRP).

UDC 621.98.002:669.14

## Half-Hot Extrusion of St35, 40Cr, 30CrMnSiN<sub>2</sub> Structural Steels

18420038d Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 9, Sep 87 pp 15-17

[Article by V.M. Alekseyev and S.V. Privalov]

[Abstract] A process of half-hot extrusion of structural steels (St35, 40Cr, 30CrMnSiN<sub>2</sub>) that is more economical in terms of both metal waste and labor cost than conventional extrusion has been developed with extensive experimentation and testing in a K849S embossing escentric-toggle press with 20 MN force capacity and 100 mm/s average travel velocity during a working stroke. The tool (die, plunger, ram) is preheated to 150-200°C and 3:1 graphite+chalk paste on water base serves as lubricant. The temperature range for both direct and indirect extrusion is 600-750°C and an extrusion factor of 40-80% is attainable. As the temperature is raised from 600°C to 750°C for a 60% extrusion factor, the pressure on the tool is dropped by 37% from 525 MPa to 330 MPa for St35 steel, by 30% from 670 MPa to 470 MPa for 40Cr steel, by 40% from 620 MPa to 370 MPa for 30CrMnSiN<sub>2</sub> steel in direct extrusion and by 21% from 1395 MPa to 1100 MPa for St35

steel, by 5% from 1435 MPa to 1360 MPa for 40Cr steel, by 27% from 1385 MPa to 1015 MPa for 30CrMnSiN<sub>2</sub> steel in indirect extrusion. Standard tensile specimens of all three thus extruded steels were tested mechanically for strength (yield strength, ultimate strength) and plasticity (percentage elongation, percentage reduction), the former somewhat decreasing and the latter somewhat increasing with higher extrusion temperature. The mechanical characteristics of the thus extruded steels were found to be much better than those of St35 steel normalized, 40Cr steel quenched from 860°C in oil and tempered at 500°C in water, 30CrMnSiN<sub>2</sub> steel quenched from 880°C and tempered at 540°C in water according to standard specifications respectively. References 3: all Russian.

2415/9604

## TREATMENTS

UDC 621.9.048.7:621.762.8

### Laser Treatment of Sintered TiC-Steel Alloys

18420042a Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV  
in Russian No 10, Oct 87 pp 57-59

[Article by V.K. Narva, N.S. Loshkareva, M.N. Kryanina and Ye.P. Shurenkov,  
Moscow Steel and Alloys Institute, All-Union Scientific Research and Design  
Institute of Refractory Metals and Hard Alloys]

[Abstract] An experimental study of 5CrWMo2 steel and TiC-steel alloys with 10-70 wt.% TiC was made for the purpose of evaluating the effectiveness of their surface hardening by laser treatment relative to conventional volume hardening by quenching in oil. Treatment was done with a continuous-wave CO<sub>2</sub>-laser, its power being varied over the 0.5-1.5 kW range. The laser beam, with various degrees of defocusing, was moved across the surface of specimens at various speeds. Microhardness and its variation over the depth of a 25 mm thick surface layer, also average hardness on the Rockwell C scale, were measured before and after treatment. Mechanical tests were supplemented with microstructural examination and fractography after cracking. The results indicate that only TiC-steel alloys with up to 30% TiC are much more surface hardened by laser treatment than volume hardened by quenching, the advantage of laser treatment being negligible for TiC-steel alloys with more than 40% TiC. Addition of TiC to the steel was found to deepen the laser-affected zone. The best results were obtained with laser treatment of the alloy containing 10% TiC, namely a wear resistance 4-5 times higher than after quenching, alloys with more than 10% TiC becoming too much prone to cracking. References 5: all Russian.

UDC 621.785.5:621.833

### Improvement and Stabilization of Strength Characteristics and Life Expectancy of Carburized and Carbonitrided Gears

18420042b Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian  
No 10, Oct 87 pp 26-29

[Article by V.M. Zinchenko, Scientific Research Technological Institute  
of the Automobile Industry]

[Abstract] Progress in both improvement and stabilization of mechanical strength and life expectancy of automotive gears by carburizing and carbonitriding is reported, gas carburizing and carbonitriding being the

preferred methods of thermochemical treatment now and most likely in the foreseeable future because of economic as well as technical advantages. Important considerations are selection of optimum temperature ranges and C,N<sub>2</sub> concentrations in the impregnating medium, prevention of hydrogen absorption leading to embrittlement, and control of the O<sub>2</sub> content as well as the C,N<sub>2</sub> contents in the case. A relation between the amount of carbides or carbonitrides and the amount of residual austenite has been established, the latter decreasing as the former is increased. The nature of defects and mechanisms of their formation in the case have been revealed by extensive microstructural examination of gear steels 35Cr, 20CrNi2Mo, 25CrMnTi, 25CrMnMo, 15CrMnNi2TiN<sub>2</sub>, 18CrMnTi, 20CrNi3N<sub>2</sub>, 12Cr2Ni4N<sub>2</sub>. Their prevention has been found to be best ensured by increasing the hardenability of a thin surface layer, which requires increasing the carbon concentration in the solid solution, as well as by inhibiting formation, dissociation, and oxidation of carbides, nitrides, and carbonitrides. Both processes can be further optimized accordingly, without any additional capital investment. B.V. Georgiyevskaya, V.A. Olovyanishnikov and V.V. Kuznetsov participated in writing this report. References 13: 9 Russian, 1 Czechoslovak, 3 Western (1 in Russian translation).

2415/9604

UDC (621.791.72.052:621.375.826):669.131.6:620,18

# Structure of Hardened Layer of Cast-Iron Sleeves After Laser Treatment

18420037a Kiev AVTOMATICHESKAYA SVARKA in Russian No 9, Sep 87 (manuscript received 6 May 86, in final version 20 Aug 86) pp 23-25

[Article by I.V. Molchan, engineer, O.A. Veliko, candidate of technical sciences, P.F. Avramchenko, engineer, N.L. Kareta, candidate of technical sciences, and A.I. Panasenko, engineer, Electric Welding Institute imeni Ye.O. Paton, UkSSR Academy of Sciences]

[Abstract] An experimental study was made concerning accelerated laser treatment, without absorbent coating, of iron sleeves for cylinders of diesel locomotive engines. Such sleeves, made of gray alloy iron (3.02% C, 1.03% Ni, 0.93% Mn, 0.48% Mo, 0.44% Cr, 0.42% Cu, 1.93% Si, 0.069% P, 0.018% S), were treated with a powerful LT 100 UKhLCh 3.6-4 kW CO<sub>2</sub>-laser at a rate of approximately 400 m/h and with a 0.6-1 mm deep penetration along a 1.1 mm wide helical track with a 3.5 mm pitch on the working inside surface, which was subsequently honed. The sleeves thus hardened were cut into specimens for metallographical-structural examination under a "Neophot" optical microscope and a JSM-35 CF scanning electron microscope with 15 kV accelerating voltage as well as for microhardness measurement and for phase analysis in a DRON-2 x-ray diffractometer with a CoK $\alpha$  - radiation source. The hardened layer was found to consist of a not easily etchable heat-affected zone containing martensite with lamellar graphite inclusions and a graphite-free white cast zone containing 21-26 wt.% martensite spread over a metastable austenite matrix along with lamellar carbides, rather than in a cementite matrix of classical ledeburite. This modification of ledeburite was also found to have a lower microhardness, and the white iron to be correspondingly less brittle. References 9: all Russian.

## Laser Welding With Thorough Fusion of Various Steels

18420037b Kiev AVTOMATICHESKAYA SVARKA in Russian No 9, Sep 87 (manuscript received 5 May 86, in final version 2 Dec 86) pp 26-29

[Article by A.G. Ignatov, engineer, A.V. Kozlov, candidate of technical sciences, A.I. Skripchenko, candidate of technical sciences, G.A. Baranov, doctor of technical sciences, I.S. Ledevich, engineer, and A.V. Surkov, candidate of technical sciences, Leningrad]

[Abstract] An evaluation of laser welding with thorough fusion and with an inert gaseous (helium) shield was made on various structural steels: 09Mn2Si hull steel, 10Ni2MnMoVN<sub>2</sub> and 22Co heat-resistant steels, 08Cr18Ni10Ti corrosion-resistant steel, and 12Ni4CrMoCuN<sub>2</sub> electroslag steel. The horizontal beam of a CO<sub>2</sub>-laser operating at half rated power was focused by an offset mirror objective with 1:8 aperture so as to form a spot 0.4-0.5 mm in diameter with a power density of 3.8-4.2 MW/cm<sup>2</sup> on both sides of the parting line between 50-120 mm wide edges of 12 mm thick and 240 mm long plates abutting without clearance. The laser beam was swept so that the spot moved along this line at a rate of 10-12 mm/s. The welded joints were cut into specimens for chemical analysis of the seam and the parent metal in an AR-3100 emission spectrometer and in an RW-1600 x-ray spectrometer, both instruments made by Philips, and for structural examination. Both the macrostructure and microstructure of the low-alloy steels were revealed by chemical etching with 5% HNO<sub>3</sub> solution in ethanol; those of the corrosion-resistant steel were revealed by electrolytical etching with aqueous 10% H<sub>2</sub>CrO<sub>4</sub> solution. Geometrical measurements were made under an MBS-9 optical microscope. The seams were found to be porous, owing to inadequate degassification of the melt, especially at the root. This deficiency can be remedied by increasing the radiation power density and by widening the counterweld. The authors thank I.Ya. Zamanov, Yu.V. Gorbatenko, I.A. Parfenov, L.F. Pavlova, and V.I. Bulatinkova for their assistance in the experiments. References 5: all Russian.

UDC 621.791.052:(669.295+669.14):620.171.18

## Properties of Alloys Forming in Transition Zone of Welded Steel-Ti Joint

18420037c Kiev AVTOMATICHESKAYA SVARKA in Russian No 9, Sep 87 (manuscript received 3 Jun 86, in final version 4 Sep 86) pp 30-33

[Article by O.G. Bykovskiy, candidate of technical sciences, I.V. Tkachenko, engineer, N.B. Tkachenko, engineer, I.V. Pinkovskiy, candidate of technical sciences, and M.M. Dzhons, candidate of technical sciences, Zaporozhye Machine Building Institute imeni V.Ya. Chubar, and V.R. Ryabov, Electric Welding Institute imeni Ye.O. Paton, UkSSR Academy of Sciences]

[Abstract] A study of 16 Ti-Fe alloys with 10-92% Fe was made for selection of suitable filler material to be used in producing welded steel-Ti joints. A special electric-arc furnace and a copper crystallizer with water cooling

have been built by the authors for smelting and casting these alloys, designed to inhibit chemical reaction of titanium with the lining material. Titanium sponge with PZh-2 iron powder was molded into bricks, which were melted and twice remelted with a tungsten electrode carrying a direct current of 400-500 A with forward polarity at a voltage of 32-36 V in an argon atmosphere under a gage pressure of 25 kPa. The melt was cast into lenticular ingots weighing 150-200 g each, with the Fe content not changed by more than 1.5%. The ingots were cut into specimens for x-ray structural examination and phase analysis in a "Kameka" microanalyzer, revealing a high degree of chemical homogeneity in conformance with the Ti-Fe constitution diagram. The series of 16 alloys was found to cover the soft ( $\alpha + \beta$ )-phase with up to 20% Fe, the harder ( $\beta + \text{TiFe}$ )-phase including the eutectic alloy with 32% Fe, the TiFe intermetallic compound and the hardest ( $\text{TiFe} + \text{TiFe}_2$ )-phase with up to 62% Fe, the friable  $\text{TiFe}_2$  intermetallic compound, and the soft ( $\text{TiFe} + \alpha_1$ )-phase with up to 92% Fe. The alloys with 50-80% Fe, being hard and brittle, are unsuitable. Those with less than 50% Fe or more than 80% Fe are satisfactory for use as filler material in production of strong welded steel-Ti joints. This has been confirmed by spot welding VT1-0 titanium to St3 plain carbon steel. References 6: 4 Russian, 2 Western.

UDC 621.791.72.052:539.38.002.234

#### Deformation of Large Articles During Electron-Beam Welding

18420037d Kiev AVTOMATICHESKAYA SVARKA in Russian No 9, Sep 87 (manuscript received 4 Mar 86) pp 54-55

[Article by O.K. Nazarenko, doctor of technical sciences, Kiev, G.F. Myal'nitsa, candidate of technical sciences, B.N. Shipitsyn, candidate of technical sciences, and R.V. Savichev, engineer, Nikolayev]

[Abstract] On the basis of favorable experience in electron-beam welding of parts up to 25 mm thick for marine gas turbines, it has been possible to establish the necessary technological parameters, including allowances for deformation during the process. Maximum and minimum radial and axial wobble before and after welding as well as after subsequent annealing in a fixture or without constraints were determined for this purpose. One example are large drum-type compressor runners made of VT-8 titanium alloy and consisting of disks with successively smaller outside diameters welded onto a shaft under compression. Another example are large trunnions made of VZh-136 heat-resistant nickel steel. Electron-beam welding, characterized by small deformation of the parts and consequently requiring little or no machining afterwards, saves 480,000 rubles in material and labor costs in one of the turbine manufacturing plants.



## Argon-Arc Hardfacing With Titanium Pins

18420037e Kiev AVTOMATICHESKAYA SVARKA in Russian No 9, Sep 87 (manuscript received 24 Mar 86, in final version 14 May 86) pp 56-58

[Article by N.M. Tarasov, candidate of technical sciences, N.A. Varukha, candidate of technical sciences, A.K. Gorlov, engineer, and Ye.P. Pogachev, engineer, Kharkov, R.V. Melnikov, engineer, and D.N. Tsaprenko, engineer, Kiev]

[Abstract] Using a pin of SPT-2 titanium alloy as a floating vertical electrode immersed in an argon arc for hardfacing blank strips of VT6s titanium alloy was studied, such an electrode melting at the lower tip and dropping a blob through a pipette onto the strip preheated by the argon arc to the melting point. The mass of this blob, a very important process parameter, was controlled as a function of the electrode diameter and maintained smaller than that of the largest blob the electrode could hold. The transfer of SPT-2 electrode material to the strip surface was controlled by intermittent acceleration of the flow of shielding gas so as to correct radial drift of the blob in the upward stream of argon from the torch and thus ensure geometrical precision of the process. Stability of the process was ensured by use of a d.c. power supply with program control for cycling the arc current. The torch nozzle was designed to ensure thorough melting of the strip surface layer for fusion with the blob. Specimens of strip hardfaced by this process were tested for shear strength and microhardness, the results indicating excellent wear resistance. The technology has been refined and equipment has been developed for its automation, this process being three times more productive than conventional resistance welding as well as much more economical in terms of both labor and material. References 3: all Russian.

2415/9604

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